

engines half speed in a severe easterly changing to northwesterly gale.

The most violent storm of the month was central south of the Aleutian Islands on the 23d and 24th. The American steamships *Dilworth* and *Las Vegas* encountered westerly gales of force 10 in  $45^{\circ}$  N.,  $166^{\circ}$  to  $170^{\circ}$  E., lowest pressure about 29.10 inches, on the 23d. On the following day the cyclone intensified and the *Las Vegas* at local noon was in a west-northwesterly gale, force 11, accompanied by rain and snow, in  $45^{\circ}$  20' N.,  $170^{\circ}$  30' E. Earlier on the 24th the Canadian S. S. *City of Vancouver* was nearer the center of the disturbance, eastward bound in a whole west gale, lowest pressure 28.73 inches, in  $45^{\circ}$  44' N.,  $174^{\circ}$  46' E. This storm by the 25th had merged with the Aleutian Low and lost greatly in intensity.

No gales were reported from Mexican and Central American coast waters. Calms and light variable winds were frequent, but gentle northwesterly winds prevailed over most of the area.

#### CYCLONIC DISTURBANCES IN THE NORTH INDIAN OCEAN

By ALBERT J. MCCURDY, JR.

Weather reports received from vessels that traversed the shipping routes of this ocean in May, 1924, indicate

551.506 (73)

#### DETAILS OF THE WEATHER IN THE UNITED STATES

##### GENERAL CONDITIONS

ALFRED J. HENRY

The outstanding feature of the month was the depression in temperature in north-central and northeastern districts and the attendant cloudy, rainy weather which greatly retarded farming operations as noted elsewhere. The temperature distribution—low in the east and high in Pacific coast States—again illustrates the great contrasts that are occasionally experienced on opposite sides of the Rocky Mountains. The usual details follow.

##### CYCLONES AND ANTICYCLONES

By W. P. DAY

High-pressure areas during May were largely of the Alberta type, some of them moving south-southeast along the eastern slope of the Rockies in a manner not unlike the movement observed in these highs during the colder season.

Pressure was low over middle latitudes east of the Mississippi River from the 6th to the 14th, with several secondary disturbances developing within this area. The most important storms coming out of this area developed considerable intensity on the middle Atlantic coast on the 7th-8th and again on the 11th and 12th.

##### FREE-AIR SUMMARY

By V. E. JAKL, Meteorologist

The mean free-air temperature for the month was below normal over all aerological stations, the deficiency being much more pronounced over the northern stations than in the South. (See Table 1.) The departure was greatest over Ellendale, where the temperature averaged more than  $4^{\circ}$ C. below normal to the upper limit of observation, and least over Due West, where it was only a fraction of a degree colder than normal. This is substan-

tially in agreement with Chart III this REVIEW, which shows, for the region east of the Rocky Mountains, negative departures diminishing in general from north to south. The departures were generally quite uniform with altitude, indicating a similarity in source of supply of air at the different altitudes included in the observations. An exception is noted at Royal Center, where the departure increased decidedly with altitude.

The source of supply of air for the different altitudes at each station is well shown in the record of wind resultants for the month determined from kite observations (Table 2), and from the auxiliary record of pilot balloon observations, the resultants from the two classes of observations being in close agreement. There was a definite positive correlation between wind direction and temperature at all levels over Ellendale, Drexel, and Broken Arrow, where a subnormal temperature was associated with winds having a decidedly more northerly trend than usual for the month. Royal Center, to the east of these stations, showed resultant winds that were approximately normal in direction but abnormal in strength. At this station a marked deficiency in temperature occurred in connection with westerly winds that had a slight northerly component in the upper levels and a rather decided southerly component in the lower levels. It is apparent that in the upper levels over Royal Center the air was transported from regions to westward, where abnormally cold northerly winds prevailed. Moreover, the free-air records on the whole indicate what is suggested by the surface observations, viz, a general circulation of the air to at least a few thousand meters depth, from northwestern to eastern sections, in conformity with the average surface pressure gradient. (See Chart VI.) Over Groesbeck and Due West, where the temperature departures were slight, the wind resultants showed no important deviation from normal.

Relative humidities were on the whole somewhat below normal, which, coupled with the lower temperatures that prevailed, indicated a low water content of

that stormy conditions prevailed off the southern coast of India and in the vicinity of Ceylon and the Maldiv Islands in the middle decade of the month.

The Dutch S. S. *Yseldijk*, Capt. C. de Korver, proceeding from Rotterdam to Australia, on May 13, encountered a moderate southeasterly gale accompanied by squally weather and rain showers. Mr. D. Treep, observer, states that the lowest pressure observed was 30.03 inches (uncorrected), occurring at 6.03 p. m., in  $16^{\circ}$  10' N.,  $89^{\circ}$  03' E. This gale lasted for two days and during that time the wind shifted from SE. to ESE.

On the 15th the American S. S. *West Mahomet*, Capt. H. Milde, Suez bound from Calcutta, ran into a moderate southwesterly gale accompanied by rough seas and overcast skies. Mr. Paul P. Zabeline, observer, reports that the lowest pressure observed was 29.70 inches, occurring at 6 p. m., in  $9^{\circ}$  10' N.,  $83^{\circ}$  E. The wind at this time was SSW., force 7.

The *West Mahomet* encountered its second gale of the month northwest of the Maldiv Islands on the 19th, reporting conditions similar to those experienced in the previous storm. The observer reports that at 5 p. m., while in  $8^{\circ}$  20' N.,  $70^{\circ}$  30' E., the lowest pressure was recorded, being 29.75 inches. The wind at this time was W., force 7, and by 8 p. m., increased to a fresh gale.

the air over most stations. This is well apparent in the record of average vapor pressures (Table 1), and is especially striking for Ellendale and Drexel, where the moisture content of the air averaged less than three-fourths of the normal amount. The northerly winds that prevailed over these two stations were, therefore, quite dry. In this respect, Royal Center was a notable exception, its record showing relative humidities in the upper levels decidedly above normal. At this station also, of all aerological stations, the most frequent precipitation and the most cloudy weather occurred. It is further significant that at Royal Center the largest lapse rate in temperature and the strongest upper-air winds occurred, from which it may be inferred that cold air from the Northwest became most effective in causing precipitation after it reached the eastern States and overran the lower winds that there had a southerly component. (See Chart IV.)

A record at Royal Center rather typical of conditions at that station during the month is that of May 3, when the kite line was struck by lightning. A low centered over Lake Michigan covered most of the northeastern portion of the country. Free-air observations showed winds from a west to southwest direction along the Ohio Valley and sections to the east, and northwesterly winds over the western Lake region and upper Mississippi Valley. It is apparent that Royal Center was near the wind shift line, and, from the following report and table, that the charge accumulated in comparatively low clouds. "The first thunder was heard in the west at 9:46 a. m. The storm came up very rapidly and it was impossible to reel the kites in soon enough to escape it. The rain and high wind beat the last secondary kite down to the ground and the others broke loose. This forced the higher kites down into the storm cloud, above which they had been flying, and consequently they were struck by lightning, burning up considerable of the wire beyond the point where the last kite had been forced down to the ground by the storm."

*Meteorological conditions over Royal Center, Ind., on May 3, 1924*

Time	Altitude, M. S. L., meters	Temperature, °C.	Relative humidity, per cent	Wind direction	Wind velocity, m. p. s.
7:24 a. m.	225 (surface)	13.0	85	S.	5
8:43 a. m.	946	9.3	73	WSW.	19
9:01 a. m.	1,833	3.1	92	W.	12
9:19 a. m.	2,453	-1.2	92	W.	18
9:23 a. m.	2,038	-2.2	47	W.	18
9:31 a. m.	3,022	-5.1	71	W.	19
9:38 a. m.	3,308	-6.1	55	W.	20

An instance of unusually severe destruction of the kite line by lightning occurred at Broken Arrow on May 28. The following extract from the report of the official in charge at that station and appended table of upper-air conditions give a full description of the circumstances under which the static discharge occurred:

For the third time lightning has struck the kite wire at this station. The latest occurrence was at 9:46 a. m. on May 28, 1924, when almost without warning, the 3,000 meters of wire was fused and 3 kites set free. The flight was started at 8:32 a. m. The sky was overcast with stratus clouds continuously during the flight and the approach of storm clouds could not be observed. There was no premonitory "kicking" of the voltmeter needle as generally precedes thunderstorms. The first thunder was heard in the southwest at 9:39 a. m. only five minutes before the final crash. At 9:38 a. m. an attempt to take voltage resulted in a startling "swish" and the lever was instantly dropped. Reeling

in was in progress at this time—the wire burst into flame from the reel to the clouds with a loud explosive noise. Then the flaming pieces of molten metal began to fall and the sound of these shot-like pieces of steel striking the ground could be heard several hundred yards away.

It is recalled that in the case of the last previous stroke there was a side discharge from the reel. Again this time there was a side discharge. The wire, as it passed outward from the reel, was not far from the flood light projector. The large bulb in this light was burned out. Otherwise the light and power circuits were apparently undamaged. The month of May has come to be our most dreaded month for thunderstorms. During May of the preceding two years there were a number of times when the kites were almost caught in an approaching storm. Kites are never put up when thunder is heard, and if up are reeled in as quickly as possible. However, there is no way to avoid such a stroke as occurred on the 28th.

*Meteorological conditions over Broken Arrow, Okla., on May 28, 1924*

Time	Altitude, M. S. L., meters	Temperature °C.	Relative humidity, per cent	Wind direction	Wind velocity m. p. s.
8:32 a. m.	233 (surface)	15.0	94	NE.	7
8:45 a. m.	608	12.9	95	ENE.	6
8:53 a. m.	880	17.1	94	ESE.	8
9:02 a. m.	1,703	14.9	90	SSW.	15
9:23 a. m.	2,600	11.5	70	WSW.	21
9:28 a. m.	2,739	10.5	55	WSW.	22
9:36 a. m.	2,600	9.4	100	WSW.	22

The intensity of the discharge can be judged from the circumstance of the incandescent light filaments having been burned out, although they were not in metallic connection with the kite wire. The record of wind direction during this kite flight is typical of certain forms of pressure distribution, where low pressure lies to the south or southwest, and high pressure to the north or northeast. A trough of low pressure extended from the Ohio Valley southwestward to Texas, and relatively high pressure prevailed over the middle and northern Plains States. The greatest change in temperature occurred above 1,700 meters, where the wind veered with altitude from SSW to WSW. In this region, previously comparatively dry, the temperature fell and cloudiness increased rapidly, as will be noted by the record at 9:37 a. m., which shows a lower temperature and higher humidity at 2,600 meters than a few minutes before. The discharge can undoubtedly be attributed to the effect of pronounced convectional activity extending above 1,700 meters to some unknown height, as the record of surface conditions shows a brief shower of rain and hail occurring soon after the discharge took place.

Winds from an easterly direction at high altitudes occurred at many stations on scattered dates throughout the month. In nearly all cases these winds occurred in a more or less stratified state, superimposed upon, or surmounted by, winds of other directions. Moreover, they were of light velocity, indicating that as a rule they were merely incidental to the conditions of light winds and variable direction with altitude that frequently accompany ill-defined pressure distribution. An example of deep easterly winds prevailing over a rather extended period, however, is furnished in the records of the Key West station, where pilot-balloon observations showed winds having an easterly component to altitudes as high as 10,000 meters, prevailing almost continuously from the 26th to 31st. These winds were probably not unusual for that latitude, and appeared to be associated with the position of the Atlantic HIGH, which lay farther south during this period than earlier in the month.

TABLE 1.—Free-air temperatures, humidities, and vapor pressures during May, 1924

Altitude. m. s. l. (m.)	TEMPERATURE (°C.)											
	Broken Arrow, Okla. (233 m.)		Drexel, Nebr. (396 m.)		Due West, S. C. (217 m.)		Ellendale, N. Dak. (444 m.)		Groesbeck, Tex. (141 m.)		Royal Center, Ind. (225 m.)	
	Mean	De- parture from 6-yr. mean	Mean	De- parture from 9-yr. mean	Mean	De- parture from 4-yr. mean	Mean	De- parture from 7-yr. mean	Mean	De- parture from 6-yr. mean	Mean	De- parture from 6-yr. mean
Surface	16.4	-3.0	13.1	-2.8	20.2	-0.2	9.5	-3.4	21.1	-1.6	14.4	-2.2
250	16.3	-3.0	13.1	-2.8	19.9	-0.2	9.5	-3.4	20.2	-1.6	14.2	-2.1
500	14.5	-2.9	12.4	-2.8	17.9	+0.1	9.1	-3.5	18.3	-1.7	11.8	-2.0
750	13.3	-2.6	10.8	-2.7	16.2	+0.2	7.1	-3.9	17.0	-1.6	9.4	-2.5
1,000	12.4	-2.3	9.2	-2.8	14.4	-0.1	5.4	-4.1	16.1	-1.2	7.5	-2.8
1,250	11.1	-2.4	7.9	-2.7	12.9	-0.1	4.0	-4.1	15.2	-1.0	5.6	-3.1
1,500	9.8	-2.5	6.6	-2.5	11.3	-0.2	2.5	-4.1	14.1	-1.0	3.7	-3.5
2,000	7.1	-2.6	4.2	-2.3	9.2	+0.2	-0.3	-4.0	11.8	-1.0	0.5	-4.1
2,500	5.3	-1.8	1.7	-2.1	5.9	-0.3	-3.4	-4.2	9.5	-0.7	-1.9	-4.0
3,000	2.5	-1.6	-0.6	-1.5	3.0	-0.4	-6.4	-4.4	7.3	-0.3	-4.8	-4.1
3,500	-0.4	-1.7	-3.1	-1.3	0.1	-0.5	-9.2	-4.6	4.4	-0.1	-8.2	-4.6
4,000	-3.9	-2.0	-6.1	-1.1	-3.3	-0.8	-12.3	-4.7	1.4	-0.1		
4,500	-7.1	-2.0	-8.1	-0.1	-6.9	-1.2	-16.0	-5.5				
5,000			-10.3	+0.9	-9.7	-0.6	-19.2	-0.3				

## RELATIVE HUMIDITY (%)

Surface	68	-5	60	-5	61	-4	57	-5	71	-1	67	+4
250	68	-5	60	-5	61	-4	57	-5	72	0	67	+4
500	66	-6	59	-5	61	-4	57	-5	74	+1	66	+3
750	64	-8	58	-5	61	-4	57	-5	75	+3	68	+5
1,000	62	-7	58	-4	62	-4	58	-4	72	+2	70	+8
1,250	62	-7	58	-4	62	-4	58	-4	66	0	72	+10
1,500	61	-5	58	-4	63	-3	58	-4	63	+1	77	+15
2,000	61	-2	55	-4	59	-7	58	-3	60	+4	76	+17
2,500	54	-5	56	-1	51	-10	62	+1	57	+5	70	+16
3,000	54	-4	52	-5	42	-14	64	+1	53	+3	64	+14
3,500	51	-3	49	-7	37	-14	57	+3	49	+2	75	+26
4,000	52	-1	59	+3	33	-12	54	+1	49	+3		
4,500	56	-1	61	+3	32	-11	64	+9				
5,000			60	0	30	-11	67	+10				

TABLE 2.—Free-air resultant winds (m. p. s.) during May, 1924

## RESULTANT WIND DIRECTION AND VELOCITY (m. p. s.)

Altitude. m. s. l. (m.)	Broken Arrow, Okla. (233 meters)				Drexel, Nebr. (396 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)			
	Mean		6-year mean		Mean		9-year mean		Mean		4-year mean		Mean		7-year mean		Mean		6-year mean		Mean		6-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	N. 67° W.	1.0	S. 21° E.	1.6	N. 50° W.	2.6	S. 8° W.	1.1	S. 69° W.	3.9	S. 62° W.	0.3	N. 10° W.	5.4	N. 33° E.	0.6	S. 10° E.	2.2	S. 15° E.	2.0	S. 83° W.	3.5	N. 44° E.	0.4
250	N. 71° W.	0.8	S. 22° E.	1.6	N. 50° W.	2.6	S. 8° W.	1.1	S. 68° W.	4.2	S. 61° W.	0.5	N. 10° W.	5.4	N. 33° E.	0.6	S. 9° E.	2.0	S. 10° E.	2.5	S. 81° W.	3.6	N. 48° E.	0.4
500	S. 85° W.	2.0	S. 12° E.	2.3	N. 47° W.	3.7	S. 12° W.	1.1	S. 73° W.	6.0	S. 80° W.	0.7	N. 9° W.	5.6	N. 46° E.	0.4	S. 5° E.	3.5	S. 3° E.	3.0	S. 69° W.	6.2	S. 51° W.	0.1
750	N. 89° W.	1.4	S. 3° E.	2.7	N. 44° W.	5.6	S. 21° W.	1.2	S. 75° W.	7.1	S. 74° W.	1.2	N.	5.6	S. 60° E.	0.5	S. 5° W.	4.0	S. 7° W.	4.1	S. 68° W.	7.3	S. 74° W.	0.6
1,000	S. 88° W.	2.1	S. 14° W.	2.9	N. 48° W.	7.4	S. 43° W.	1.8	S. 79° W.	7.4	S. 84° W.	1.7	N. 5° W.	5.6	S. 18° E.	0.7	S. 18° W.	4.2	S. 20° W.	4.6	S. 73° W.	8.9	W.	1.2
1,250	N. 81° W.	2.9	S. 33° W.	3.0	N. 51° W.	8.4	S. 53° W.	2.3	S. 82° W.	8.4	S. 76° W.	2.8	N. 6° W.	5.7	S. 8° W.	1.0	S. 34° W.	4.1	S. 28° W.	4.9	S. 75° W.	8.7	N. 77° W.	1.6
1,500	N. 79° W.	3.9	S. 44° W.	3.3	N. 53° W.	9.5	S. 61° W.	3.0	S. 84° W.	10.1	S. 72° W.	4.0	N. 16° W.	6.3	S. 24° W.	1.4	S. 48° W.	3.9	S. 38° W.	4.8	S. 82° W.	8.6	N. 80° W.	2.2
2,000	N. 62° W.	6.2	S. 67° W.	4.0	N. 54° W.	11.1	S. 74° W.	4.2	S. 87° W.	11.8	S. 78° W.	5.3	N. 29° W.	7.0	S. 45° W.	2.3	S. 62° W.	3.6	S. 50° W.	4.8	S. 88° W.	9.6	N. 84° W.	3.2
2,500	N. 65° W.	9.6	S. 87° W.	5.3	N. 59° W.	11.6	S. 82° W.	4.9	N. 89° W.	12.8	S. 83° W.	6.7	N. 43° W.	7.9	S. 50° W.	3.8	S. 82° W.	4.8	S. 87° W.	5.4	N. 87° W.	11.7	N. 84° W.	4.2
3,000	N. 66° W.	11.4	N. 81° W.	6.3	N. 62° W.	13.2	S. 85° W.	7.1	S. 82° W.	13.5	W.	8.4	N. 48° W.	9.3	S. 60° W.	5.0	N. 75° W.	7.4	S. 81° W.	6.9	N. 85° W.	14.4	N. 81° W.	5.5
3,500	N. 72° W.	12.7	N. 74° W.	9.3	N. 62° W.	12.0	S. 89° W.	8.2	S. 82° W.	14.4	N. 83° W.	8.4	N. 55° W.	10.4	S. 72° W.	5.0	N. 65° W.	13.0	N. 88° W.	8.6	N. 84° W.	16.6	N. 69° W.	6.8
4,000	N. 83° W.	12.0	N. 67° W.	11.3	N. 85° W.	11.8	N. 84° W.	8.9	S. 85° W.	15.0	N. 75° W.	10.8	N. 51° W.	11.0	S. 83° W.	5.0	N. 56° W.	13.8	N. 66° W.	12.2				
4,500	N. 72° W.	17.9	N. 65° W.	17.9	N. 79° W.	13.5	S. 78° W.	10.5	W.	13.7	N. 69° W.	10.4	N. 45° W.	10.9	N. 76° W.	3.3	N. 45° W.	13.8	N. 59° W.	14.1				
5,000	N. 45° W.	26.0	N. 45° W.	26.0	N. 75° W.	14.6	N. 86° W.	16.0	W.	14.0	N. 80° W.	15.3	N. 67° W.	14.1	N. 45° E.	3.3								

## THE WEATHER ELEMENTS

By P. C. DAY, Meteorologist, in Charge of Division

## PRESSURE AND WINDS

The marked persistence of low atmospheric pressure, and the frequency of moderate cyclonic conditions over the districts from Mississippi Valley eastward, and the movement southward from Alberta along the eastern slopes of the Rocky Mountains and over the Great Plains of several anticyclones, favored the prevalence of northerly and westerly winds over much of the country from the Rocky Mountains eastward. As a result of

TABLE 1.—Free-air temperatures, humidities, and vapor pressures during May, 1924—Continued

Altitude. m. s. l. (m.)	VAPOR PRESSURE (mb.)											
	Broken Arrow, Okla. (233 m.)		Drexel, Nebr. (396 m.)		Due West, S. C. (217 m.)		Ellendale, N. Dak. (444 m.)		Groesbeck, Tex. (141 m.)		Royal Center, Ind. (225 m.)	
	Mean	De- parture from 6-yr. mean	Mean	De- parture from 9-yr. mean	Mean	De- parture from 4-yr. mean	Mean	De- parture from 7-yr. mean	Mean	De- parture from 6-yr. mean	Mean	De- parture from 6-yr. mean
Surface	13.02	-3.70	8.81	-3.15	14.88	-0.82	6.23	-3.19	17.87	-2.01	11.06	-0.92
250	12.88	-3.69	8.81	-3.15	14.64	-0.78	6.23	-3.19	17.24	-1.81	10.86	-0.90
500	11.12	-3.46	8.25	-3.06	13.03	-0.58	6.05	-3.12	15.85	-1.37	9.09	-0.92
750	10.09	-3.01	7.20	-2.77	11.72	-0.64	5.36	-2.70	14.96	-0.63	8.11	-0.72
1,000	9.44	-2.52	6.50	-2.50	10.47	-0.75	4.87	-2.42	13.37	-0.60	7.28	-0.63
1,250	8.45	-2.30	6.01	-2.15	9.44	-0.74	4.50	-2.20	11.35	-0.55	6.73	-0.58
1,500	7.59	-1.81	5.56	-1.80	8.44	-0.74	4.13	-1.96	9.70	-0.59	6.24	-0.58
2,000	6.28	-1.24	4.44	-1.38	6.26	-1.14	3.43	-1.43	7.84	-0.19	4.74	-1.14
2,500	4.82	-0.98	3.77	-0.92	4.36	-1.64	2.86	-0.95	6.63	+0.23	3.70	-0.09
3,000	3.86	-0.62	2.92	-0.89	2.79	-1.93	2.19	-0.80	5.51	+0.21	2.87	-0.30
3,500	3.12	-0.61	2.12	-0.92	1.81	-1.07	1.85	-0.67	4.55	+0.33	2.97	-0.93
4,000	2.62	-0.63	1.86	-0.57	1.14	-1.85	1.13	-0.58	3.90	+0.39		
4,500	2.28	-0.53	1.40	-0.61	0.64	-1.64	0.74	-0.48				
5,000			1.04	-0.63	0.31	-1.59	0.29	-0.53				

this inflow of air from higher latitudes or more elevated regions the weather continued cold over the districts between the Rocky Mountains and the Mississippi Valley, and almost constant cold, cloudy, rainy weather prevailed during the month over much of the country from the Mississippi Valley eastward.

The most important cyclone of the month in its general effect upon the weather first assumed prominence in the lower Missouri Valley on the morning of the 5th, and, with secondary disturbances that developed within the main low pressure area, or that combined with it in its slow eastward movement, dominated the weather over the districts from the Mississippi Valley eastward until after the end of the first decade. During this